Evaluation of Glare at the Ivanpah Solar Electric Generating System

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NNSA National Nuclear Security Administration

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Overview

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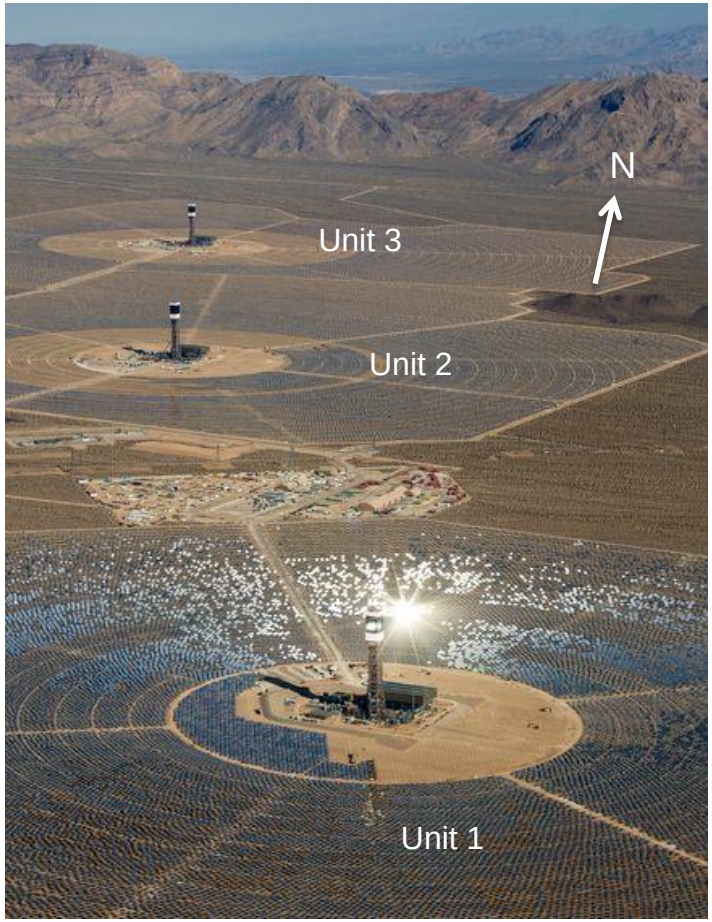
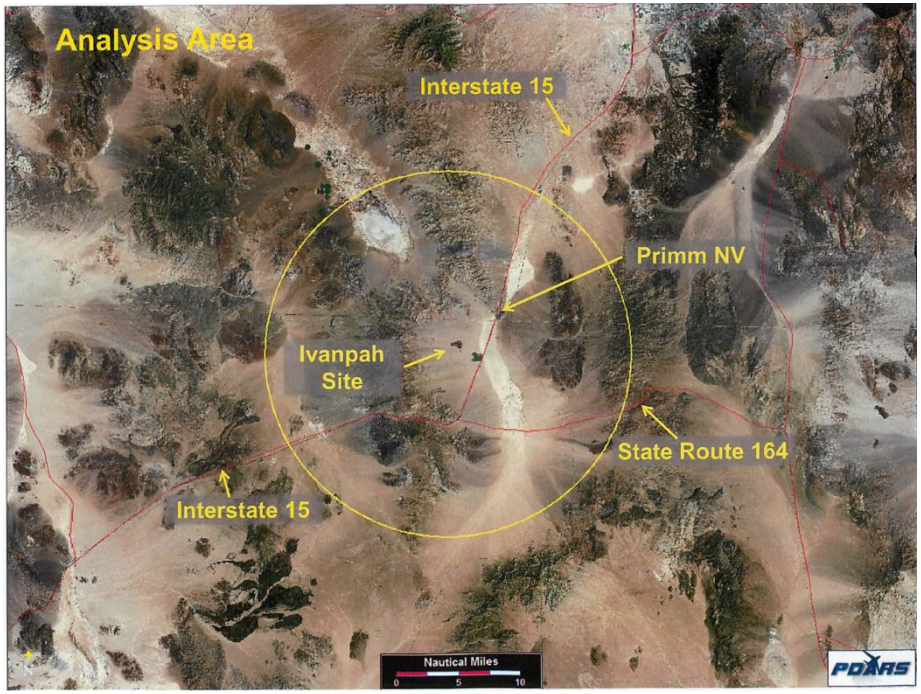
- Background and Requirements
- Glare Monitoring
  - Aerial Survey
  - Ground Survey
- Mitigation Methods
- Next Steps

Ivanpah Solar Electric Generating System

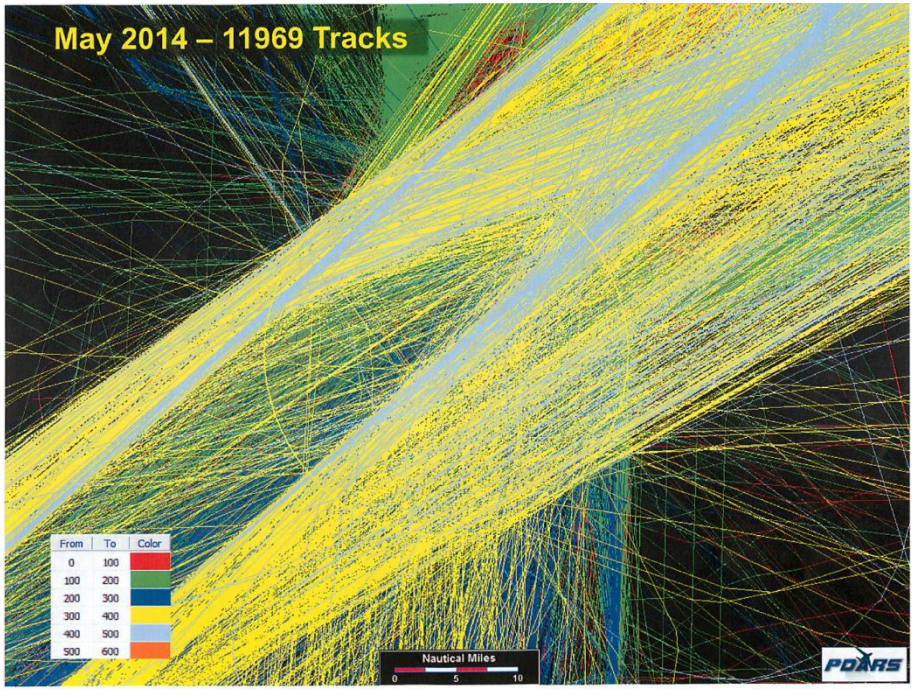
- Three power tower units
  (377 MW (net) / 392 MW (gross)
  - Unit 1: 126 MW
  - Unit 2: 133 MW
  - Unit 3: 133 MW
  - Each tower 140 m (459 ft) tall
- 173,500 heliostats
  - 2 mirrors/heliostat: 15.2 m^2
- Direct steam receiver (22 m tall x 17 m wide + ~16 m of white shielding)
- Dry-cooling
- 14.2 km^2 (3500 acres) on public desert land in southern California
- Owners: NRG Energy, Google, and Brightsource Energy



Flight Path Analysis near ISEGS



FAA evaluated number of flight paths within 15 nautical miles of ISEGS (Docket 09-AFC-07C, TN 202585)



Nearly 12,000 flights in May 2014

Reports of Glare

- Docket Number 07-AFC-05C, TN#201847 “Letter re Pilot Complaints of Visual Impacts from Ivanpah Solar Electric Generating System,” 3/10/2014
  - ACN: 1109473
    - “At its brightest neither the pilot nor co-pilot could look in that direction due to the intense brightness. From the pilot’s seat of my aircraft the brightness was like looking into the sun... In my opinion the reflection from these mirrors was a hazard to flight because for a brief time I could not scan the sky in that direction to look for other aircraft.”
  - ACN: 1108698
    - “Daily, during the late morning and early afternoon hours we get complaints from pilots of aircraft flying from the northeast to the southwest about the brightness of this solar farm.”
- Sent to NRG from CEC on 4/16/2014
  - ACN: 1156120
    - “While on the KEPEC3 arrival into LAS we were temporary blinded by bright lights (reflections) from the ground. These reflections, coming from the new solar power station were so bright that any attempt to look outside the plane was met with pain and temporary blindness even when looking back inside.”

Request from Clark County Department of Aviation (CCDOA) – March 10, 2014

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- Actions
  - Make efforts to observe the glare noted in the complaint (done)
  - Documentation of aerial monitoring of potential exposure to pilots, including visual observation and video recordings during three helicopter flyovers
  - Results of luminance evaluations as required in Section D.1 of TRANS-4 of the Power Tower Receiver Luminance and Monitoring Plan

Monitoring Requirements

(per TRANS-3, -4, the HPP, and the PTLMP)

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Prepared by Environmental Planning Group for CH2MHILL Engineers, Inc., and NRG

Task	Frequency	Status
Evaluate the intensity of the luminance light reflected from the power tower receiver. Measurements of luminance are required where distractions are reported, at the 4 sides of the power plant boundaries, at the nearest public roads.	Within 90 days following commercial operation; after 5 years of operation, after major design changes & following legitimate complaints.	Data collected
Luminance evaluations need to be coordinated with 7 agencies. Arrange and facilitate agency meetings and consultations	Weekly for 1st 3 months of operation (13 times), monthly thereafter (at least 24 times)	In progress
Procure, test and install stationary camera apparatus and software. Locations of ground-based cameras to be determined in cooperation with agencies.	As soon as practical	N/A
Conduct ground monitoring	At least weekly until static cameras are installed	Data collected for three times of the day
Conduct aerial monitoring to determine the potential for impacts to aviation	ASAP, after 5 yrs of operation and after changes to the project that affect luminance	Data collected
Analyze monitoring results	Weekly until real-time analysis is possible, then constant during operations	In progress
Investigate complaints	Within 10 days, as needed	Done
Investigate identified potentially significant glint and glare events	As needed	Done

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Aerial Survey

Helicopter Survey (April 24, 2014)

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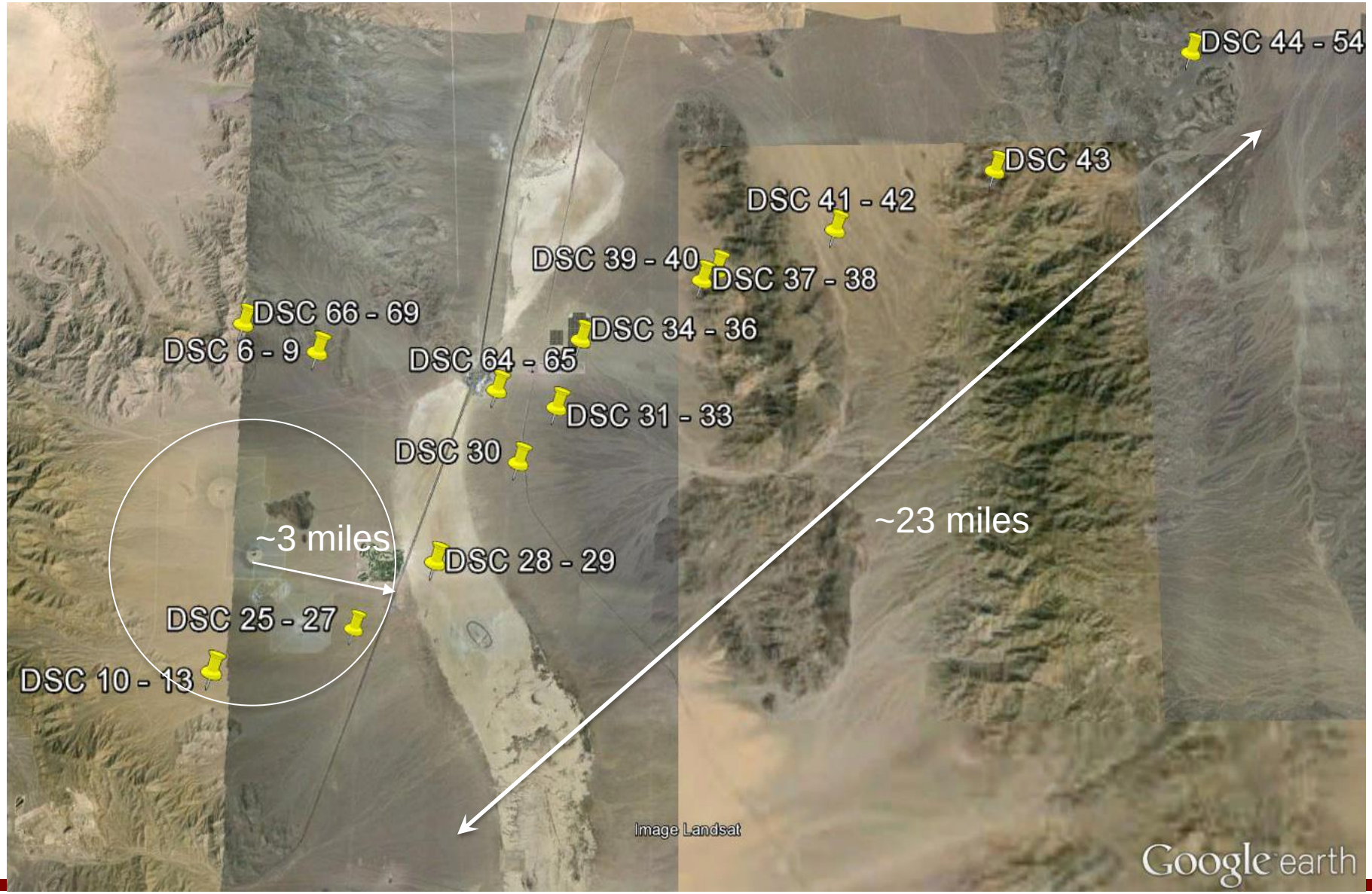
Aerial Monitoring Photo Locations



Aerial Glare Video

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9:23 AM (PDT), April 24, 2014

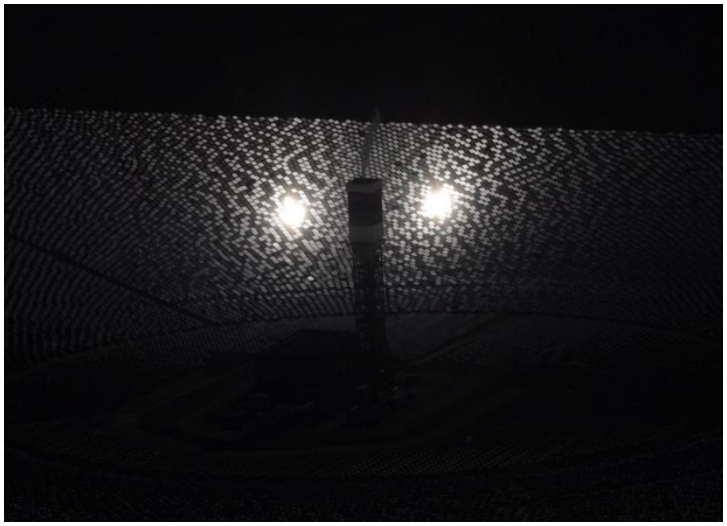
Aerial Glare Video

Glare from Unit 1 heliostats aimed at standby points on ***both*** sides of the receiver; looking south/southeast (~0.6 miles from tower)

9:29 AM (PDT), April 24, 2014

Filtered Images of Heliostat Glare

Looking Northeast at Unit 1, 9:10 AM PDT (~3 miles away from glare)



Ocular Hazard Analysis

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Image	Tower Unit	Approximate Distance to Glare (miles)	Peak Retinal Irradiance (W/cm^2)	Total Subtended Glare Angle (mrad)	Ocular Impact
DSC 26	1	**1**	6.39	4.13	**Potential for Temporary After-Image**
DSC 28	1 (left)	**3**	5.10	1.60	**Potential for Temporary After-Image**
DSC 28	1 (right)	**3**	2.81	1.90	**Potential for Temporary After-Image**
DSC 08	3	**4**	2.12	3.64	**Potential for Temporary After-Image**
DSC 08	3 v2	**4**	1.98	4.03	**Potential for Temporary After-Image**
DSC 30	1	**6**	2.15	3.47	**Potential for Temporary After-Image**
DSC 65	1	**6**	4.25	1.60	**Potential for Temporary After-Image**
DSC 32	1	**7**	5.45	1.06	Low Potential for After-Image
DSC 34	1	**11**	5.29	0.586	Low Potential for After-Image
DSC 41	3	**15**	1.39	0.760	Low Potential for After-Image
DSC 53	3	**23**	0.112	0.541	Low Potential for After-Image

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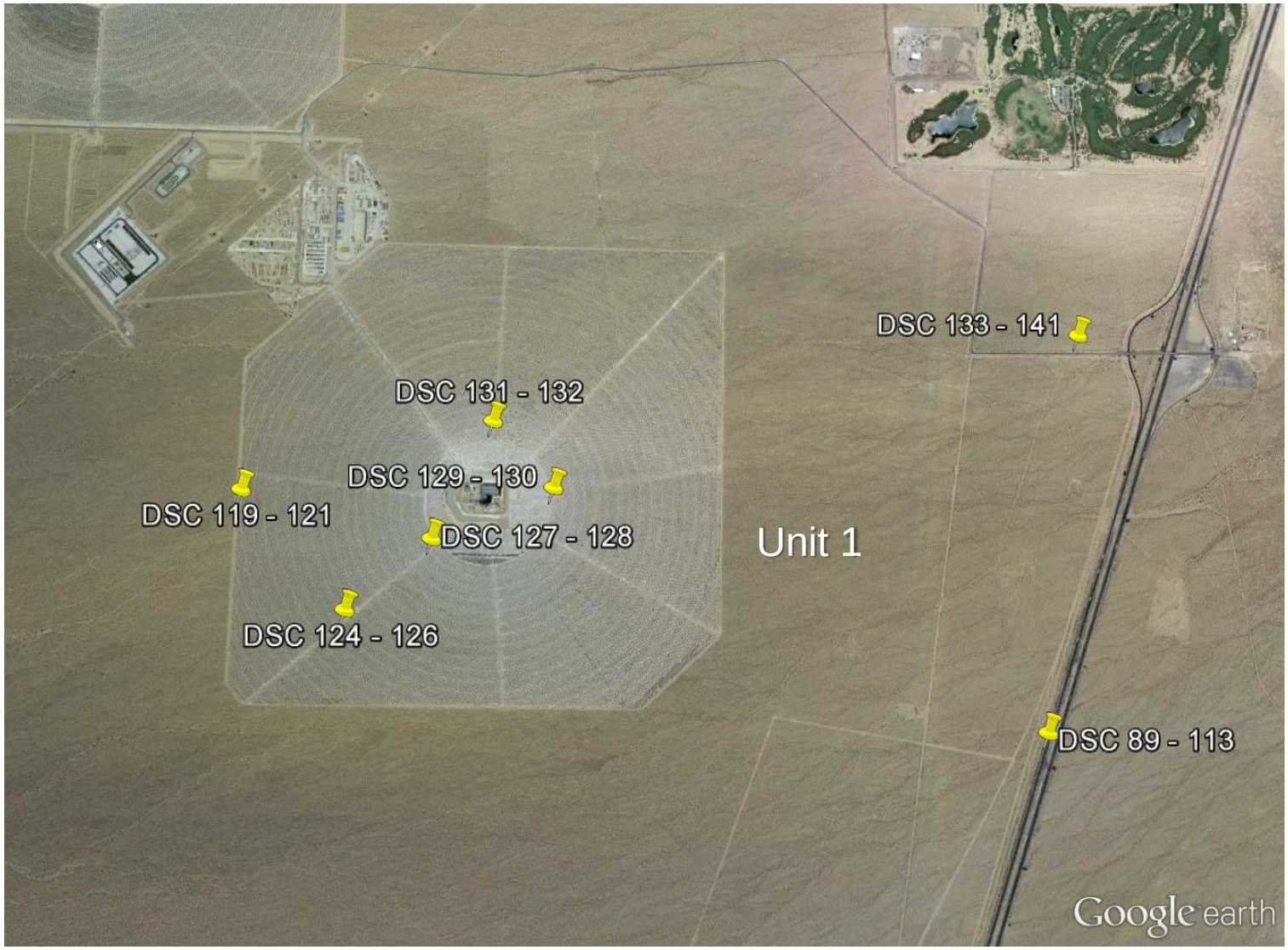
Ground Survey

Ground Monitoring Photo Locations



Drive-by Video

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~12:20 PM (PDT), April 24, 2014

View of Unit 3 Receiver Glare and Rogue Heliostat from I-15

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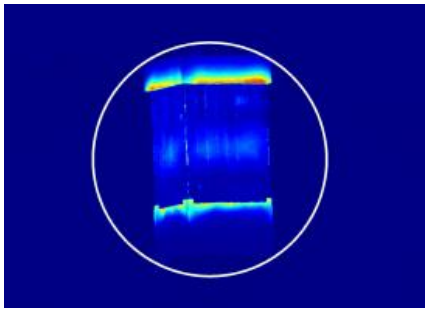
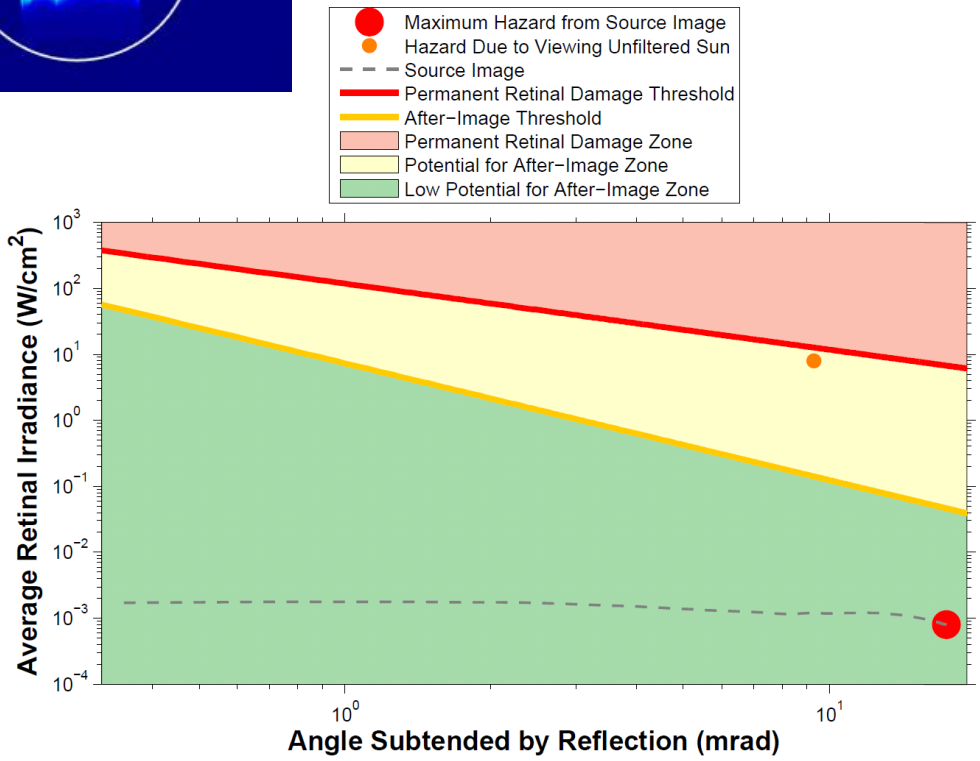
~5 miles

Receiver Ocular Hazard Analysis

View of Unit 1 Receiver from I-15 ~1.5 miles away





Summary of Glare Monitoring

- Aerial Monitoring
  - Heliostats in standby mode can cause glare to aerial observers (pilots)
  - Glare from heliostats can cause after-image at far distances (up to 6 miles in our helicopter surveys)
  - Glare was visible from multiple heliostats in standby mode
  - The glare from the illuminated receiver was small compared to the glare from the standby heliostats
- Ground Monitoring
  - Drive-by surveys at three different times of the day did not reveal any ocular hazards
  - All data from receiver glare showed a low potential for after-image

Ryan Goerl, NRG

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Mitigation Methods

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- Letter to Airmen notifying pilots of potential glare from ISEGS issued by FAA on May 5, 2014
- Develop new strategy for heliostat standby position to reduce number of heliostats that can reflect light to an aerial observer
  - Increase the number of aim points near the receiver and have adjacent heliostats point to different locations
  - Position heliostats vertically in proper azimuth position
  - Bring heliostats up to standby position at top of receiver sequentially as needed
  - Incorporate a glare shield near the receiver that can serve as both the aim point for heliostats in standby mode and a preheater for the water entering the receiver

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Next Steps

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- From CCDOA letter 3/10/14:
  - Address the complaint(s) as soon as practical and report the results to Bureau of Land Management (BLM) Needles Field Office, California Energy Commission (CEC), CCDOA and the other agencies identified in Section 6.5 of the HPP
- Per TRANS-3, -4, the HPP, and the PTLMP (Prepared by Environmental Planning Group for CH2MHILL Engineers, Inc., and NRG)
  - The plans require the ISEGS project owner to coordinate with the CEC, BLM, Caltrans, California Highway Patrol, Federal Aviation Administration, the U.S. Navy, and Clark County Airport (collectively referred to as participating agencies) to implement the plans, monitor results, resolve complaints, and to take corrective or mitigation actions

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Backup Slides

Next Steps – Tower Illuminance Model

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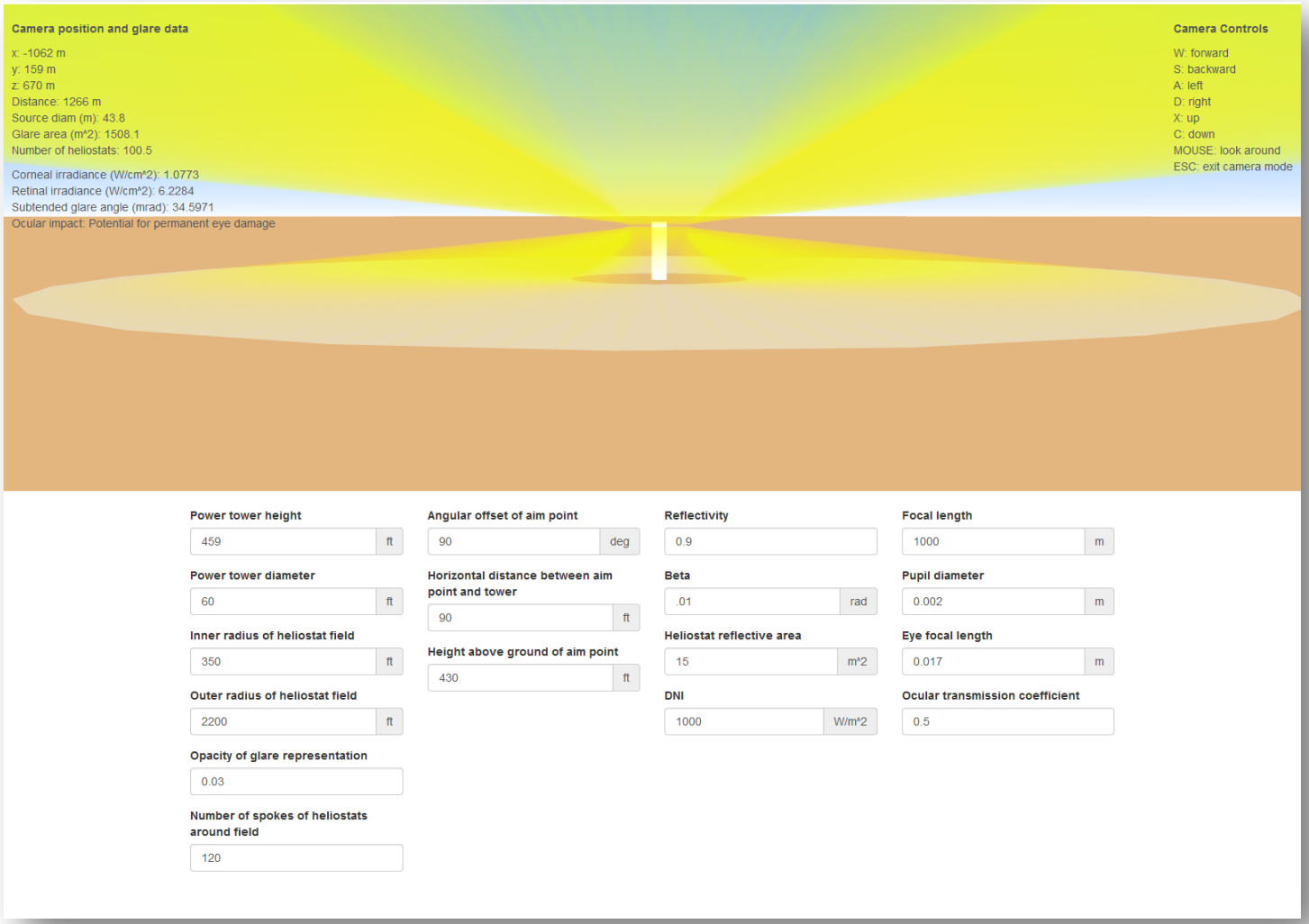
Sandia is developing a 3D tool (with DOE funding) that allows us to “fly” around a power tower plant to determine the irradiance and potential ocular hazards from heliostat glare at any location



Receiver Irradiance

- Unit 1, East Panel, 265 m away, 3:38 PM PDT